MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

ZAPORIZHZHA NATIONAL TECHNICAL UNIVERSITY

Methodical Instructions

to laboratory works on discipline
"The basics of electronics and microcircuitry" part 1
for students of specialty
141 -"Electrical power engineering, electrical engineering and electromechanics" of all forms of education

2019

Methodical Instructions to laboratory works on discipline "The basics of electronics and microcircuitry" part 1 for students of specialty 141 -"Electrical power engineering, electrical engineering and electromechanics" of all forms of education /Comp.: M.O.Polyakov, L.S. Skrupskaya. – Zaporizhzha: ZNTU, 2019. – 36 p.

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CONTENT

INTRODUCTION

The purpose of the laboratory work is to consolidate the theoretical material from the discipline "Fundamentals of Electronics and Microcircuits" into Part 1 "Electronic Devices and Base Units" in practice. For the study of electronic devices and nodes, the Electronics Workbench (EWB) circuit design model is used - the development of the company Interactive Image Technologies. The advantage of computer simulation is the large variety of electronic elements and measurement tools to create an electronic circuit, the impossibility of its damage and a high level of electrical safety.

The guidelines provide a description of 8 laboratory work on the topics of the study of the user interface of Electronics Workbench, semiconductor diodes, bipolar transistors, thyristors, electronic amplifiers, operational amplifiers, logic elements and filters.

The student is obliged to study the theoretical material [1-4], perform practical tasks and make a report on laboratory work, which will have the main sections:

- Name of laboratory work;
- Its purpose;
- Schemes of experiments, tables, graphs, calculations, conclusions.

The report must be made in accordance with СТП 1596 and protected.

Laboratory work №1

Objective: to learn the interface of the program Electronics Workbench, get skills of construction of electric charts and use of oscillograph.

Short theoretical data: Electronics Workbench (EWB) is development of firm Interactive Image Technologies. The feature of the program Electronics Workbench is a presence of control and measuring devices that after a kind, to the management organs and descriptions, maximally close to their industrial analogues, that gives an opportunity to get practical skills in-process with the most widespread devices: by a multimeter, oscillograph, by generators and other Program is easily studied and easy-to-use enough. After the stowage of chart a design begins to the кліком mouse on a switch on the screen of the program. Recommended literature - web-site of program producer - www.interactiv.com.

Motion of work

Experiment №1

1 To lay down the chart of the resistance divisor of voltage, represented on fig. 1.1.

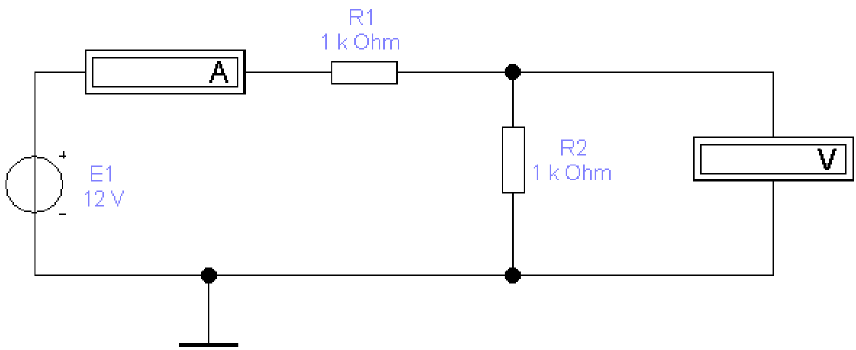


Figure 1.1 –Scheme of resistive voltage divider

2 Determine the current flowing through the resistor R1 and the voltage on the resistor R2, add them to the table. 1.1. Take off the instrumentation for several voltage values of the power supply E1. Construct a graph of current dependence on voltage.

Table 1.1 – Devices show

I, mA								
U, V								

Experiment №2

3 Make a circuit of a single-phase bridge rectifier, working on an active load, depicted in Fig. 1.2.

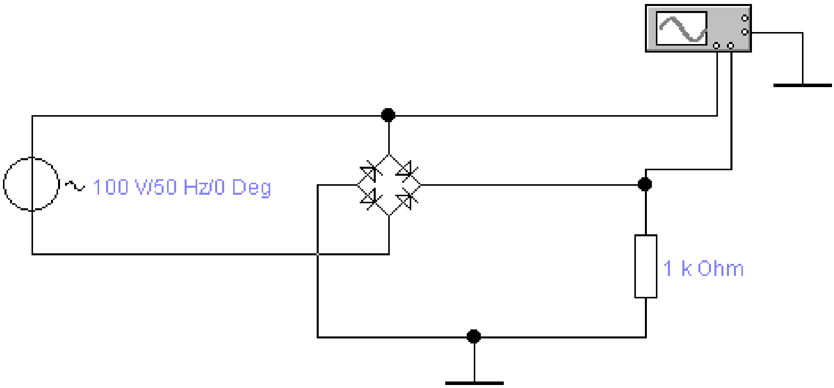


Figure 1.2 – Scheme of single-phase bridge rectifier, working on active load

4 Remove oscillogram.

Control questions

1. Features and objectives of the Electronics Workbench program.
2. How to print a circuit diagram on a printer?
3. What team can I copy the schema into the report?
4. How to change the color of the conductor and when to do it?
5. Which command can assign the component of the circuit a positional value and which rule is used in this case?
6. How can the parameters of the components of the scheme (for example, model, face value, temperature, fracture, etc.) be specified?
7. What is the component of the "node" scheme used for?

Laboratory work №2

Objective: to obtain the skills of simulation of diode circuits, to study the direct and reverse branches of the VAC diode.

Brief theoretical data: The semiconductor diode is an electronic device with a nonlinear voltage-current characteristic (VAC) [1]. With the help of Electronics Workbench it is easy to simulate and measure the voltage on the diode and the diode current, connecting it to the voltage source of different rating through the resistor. Depending on the polarity of the diode's activation, each result of the current and voltage measurements corresponds to a point on the direct or reverse branch of the VAC of the diode. The measurement results are influenced by the resistance of the measured devices. Therefore, the circuits for measuring the direct and reverse branches of the VAC are somewhat different.

Motion of work

Experiment №1

1 Draw a diagram depicted in Fig. 2.1.

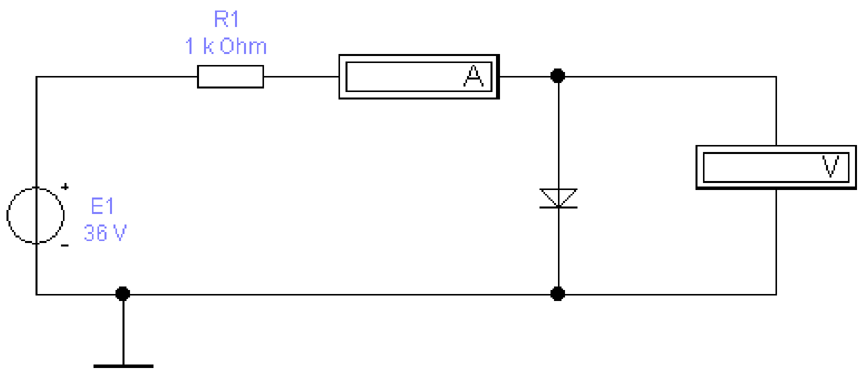


Figure 2.1 - Diagram of research of direct branch of VAC diode

2 When changing the voltage E1 or resistance R1, take measurements of the measuring devices and add them to the table. 2.1.

3 According to Table 2.1, to construct a graph of the straight line of the VAC.

4 According to Table 2.1, calculate the resistance of the Rd diode by direct current and construct a dependency curve based on the voltage on the diode.

Table 2.1 – Impressions of Measured Devices

U1,V							
I1,mA							
R_d, Ω							

Experiment №2

5 According to the variant number, choose a diode from the table. 2.2.

6 Collect the diagram shown in Fig. 2.2.

Table 2.2 – Options for diodes

№ variant	1	2	3	4	5	6	7	8	9	10	11	12
Diode	1N4148	1N4149	1N4150	1N4151	1N4152	1N4153	1N4154	1N4305	1N4446	1N4447	1N4448	1N4449

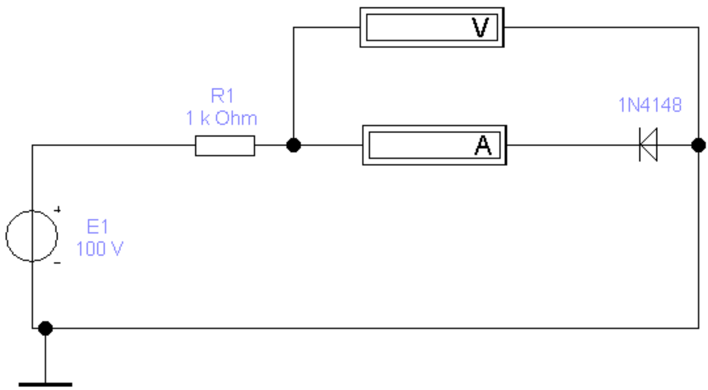


Figure 2.2 – Scheme of the study of the reverse branch of the VAC diode

7 By changing the voltage E1, get the VAC points and add them to the table. 2.3.

Table 2.3 Impressions of Measured Devices

E1, V				
I1, mA				
U1, V				
R, kΩ				

8 Build a timing diagram of a VAC diode.
9 Determine the breakdown voltage.
10 Write the diode parameters in the report.

Control questions

1. How to determine the current through the diode?
2. Why are different circuits used to study the direct and reverse side of VAC?
3. How to determine the resistance of the diode for DC, differential resistance?
4. When is the extraction and injection of current carriers in the diode?
5. Ividence of the breakdown of the diode: definition, mechanisms, area on the VAC?
6. What is the real diode from the ideal?

Laboratory work №3

Objective: to investigate the VAC of a bipolar transistor in a general emitter scheme.

Brief theoretical data**:** The bipolar transistor is a semiconductor device used to amplify current and (or) voltage in electronic amplifiers [1]. The family of output characteristics of the transistor according to the scheme with the common emitter (CE) is described by the dependence $I_C = f(U_{CE})$ with $I_B = const$. In turn, the family of input characteristics of the transistor by the scheme of CE is described by the dependence $I_B = f(U_{BE})$ with $U_{CE} = const$.

Static current transfer coefficient of the base is defined as the ratio of collector current: I_C to base current I_B :

$$\beta_{DC} = \frac{I_C}{I_B}.$$

The difference coefficient of current transfer of the base β_{AC} AC is determined by the output VAC as the ratio of the gain ΔIc of the collector current to the causing its increase ΔIb of the base current at a fixed value of the voltage collector-emitter:

$$\beta_{AC} = \frac{\Delta I_C}{\Delta I_B}.$$

Differential input resistance of r_{IN} transistor in the circuit with CE is determined by the input VACs at a fixed value of the collector-emitter voltage. It can be found as the ratio of the voltage gain ΔU_{BE} to the base-emitter to the gain caused by it ΔI_B base current:

$$r_{IN} = \frac{\Delta U_{BE}}{\Delta I_B}$$

Similarly, in the output VAC, the output impedance of the transistor rOUT in the circuit with the total emitter is determined:

$$r_{OUT} = \frac{\Delta U_{CE}}{\Delta I_C}$$

Motion of work

Experiment №1

1 Draw a pattern of rice. 3.1. Transistor for the circuit to choose according to the number of the variant from the table. 3.1.

Table 3.1 – Options for transistors for the circuit

Variant	1	2	3	4	5	6	7	8	9	10	11	12
of transistor	BC107BP	BC108BP	BC109BP	BC182BP	BC183BP	BC184BP	BC237BP	BC238BP	BC239BP	BC413BP	BC414BP	BC546BP

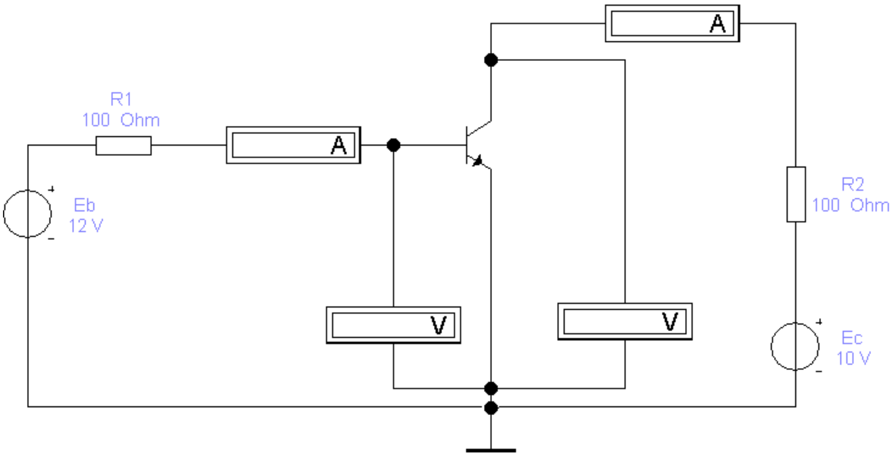


Figure 3.1 – Scheme for the research of a transistor VAC with a common emitter

2. Measure IC and U_{CE} by setting I_B as shown in Table. 3.2.

3 Build a timetable for a family of output characteristics. According to the graph, determine the gain of the transistor and the output impedance.

4 Write in the report the parameters of the transistor model from the properties window of the component.

Table 3.2 – Experiment results

I_B=0 mA	I_C, mA									
	U_{CE}, V									
I_B=0,001 mA	I_C, mA									
	U_{CE}, V									
I_B=0,002 mA	I_C, mA									
	U_{CE}, V									

I_B=0,01 mA	I_C, mA									
	U_{CE}, V									

Experiment №2

5.Set the U_{CE} voltage to (0; 10) volt by changing the E_C.

6 When changing E_C, get the voltage U_{BE} in the range from 0 to 0.75 volts (at least 10 values). For each U_{BE} to record I_B, the results are recorded in the table. 3.3.

7 Construct a graph of input characteristics $I_B = f(U_{BE})$, at U_{CE} = const. According to the graph, determine the input impedance of the transistor.

Table 3.3 - Experiment results

U_{CE}= 0,V	E_C, V									
	U_{BE}, V									
	I_B, mA									
U_{CE}= 10,V	E_C, V									
	U_{BE}, V									
	I_B, mA									

Control questions

1. Principle of operation, varieties, operating modes, switching circuits, characteristics and models of the bipolar transistor.
2. What does the collector current of the transistor depend on?
3. What expression describes the output characteristic of the transistor, and under what condition is it valid?
4. What is the expression describing the input characteristic of the transistor, and under what condition is it valid?
5. Does the β_{DC} coefficient depend on the collector current? If so, then which degree?
6. What can be said on the initial characteristics of the dependence of collector current on the current of the base and the voltage collector-emitter?
7. What parameters of the transistor can be determined by its input and output VAC?

Laboratory work №4

Objective: Explore a transistor amplifier.

Brief theoretical data: in this paper, the principle of calculating a one-stage amplifier with CE is investigated. When calculating the cascade transistor is replaced by its simplified equivalent circuit. Cascade calculation is performed in two stages. The calculation of constant components allows you to find the parameters of the working point of the transistor cascade. Calculation of the variable components is the enhancement of the cascade properties at this point.

By using an equivalent circuit, the constant components of the current of the base of the I_{BP}, the current of the I_{CP} collector and the voltage on the U_{CP} collector are found. They are defined by the following expressions:

$$I_{BP} = \frac{E_{ECV} - U_{BE0}}{R_B}$$

$$I_{CP} = \beta \cdot I_{BP}$$

$$U_{CP} = E_C - I_{CP} \cdot R_C$$

An alternating current circuit allows you to determine the amplitudes of the alternating current components of the base IB-M, the collector current IC-M, the voltage on the collector. With a known value of the amplitude of the voltage of the generator EGM, the amplitude of currents and voltages can be determined by the following expressions (the sign M denotes the amplitude of the variable):

$$I_{B-M} = \frac{E_{GM}}{R_{IN}}$$

$$I_{C-M} = \beta \cdot I_{B-M}$$

$$U_{C-M} = I_{C-M} \cdot R_{ECV}$$

The obtained expressions allow to determine the voltage gain (K) as the ratio of the amplitude of the output voltage to the input:

$$K = \frac{U_{B-M}}{E_{GM}} = \beta \cdot \frac{R_{ECV}}{R_{IN}}$$

Instantaneous values of currents and voltages are the sum of constant and variable components. The corresponding oscillograms are shown in Fig. 4.1.

The oscillograms of the alternating current components of the base I_B and the current collector I_C have the same shape, because the corresponding instantaneous values are proportional:

$$I_C = \beta \cdot I_B$$

The maximum value of collector current can not exceed the saturation current value:

$$I_{CM} = E_C / R_C$$

This current corresponds to the saturation current of the base:

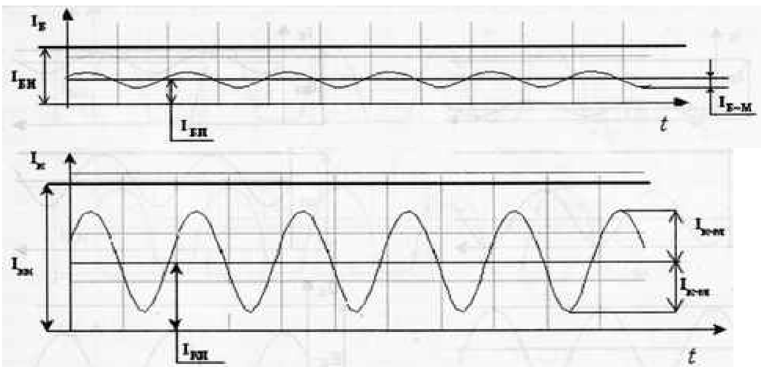
$$I_{BN} = \frac{I_{CN}}{\beta} = \frac{E_C}{\beta \cdot R_C}$$

The instantaneous value of the voltage on the collector is determined by the expression:

$$U_C = E_C - I_C \cdot R_C$$

Oscillograms shown in Fig. 4.1, received for UCP mode = E_C / 2. In this case, you can obtain the maximum value of the undistorted output voltage, the maximum value of which amplitude is equal to half the voltage of the power supply E_C.

The considered oscillograms (Fig 4.1) correspond to the linear mode of the amplifier's operation.



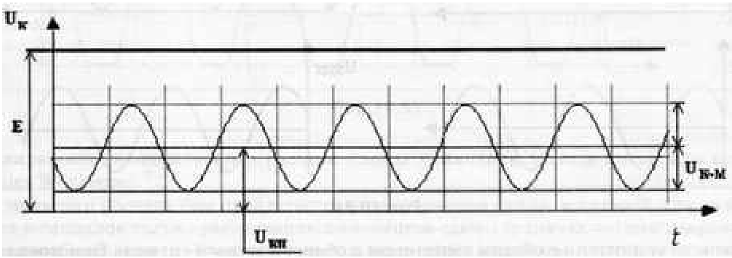


Figure 4.1 – Oscilloscope of the amplifier in linear mode

Motion of work

Experiment №1

Specifying a work point

1 Gather the scheme shown in Fig. 4.2. In the scheme use the transistor, selected from the table. 4.1 according to the option.

2 When changing R1 to get Ups (attention, switches S1, S2 must be in the position shown in Figure 4.2, S1 is open, and S2 is locked).

3 Calculate collector current for a resting point.

Table 4.1 – Models of transistors and data for experiment number 1

№ variant	1	2	3	4	5	6	7	8	9	10	11	12
Transistor (zetex)	BC107BP	BC108BP	BC109BP	BC182BP	BC183BP	BC184BP	BC237BP	BC238BP	BC239BP	BC413BP	BC414BP	BC546BP
E, B	10	11	12	13	14	16	17	18	19	20	21	22
Uсп, B	5	5	6	6	7	8	8	9	9	10	11	11

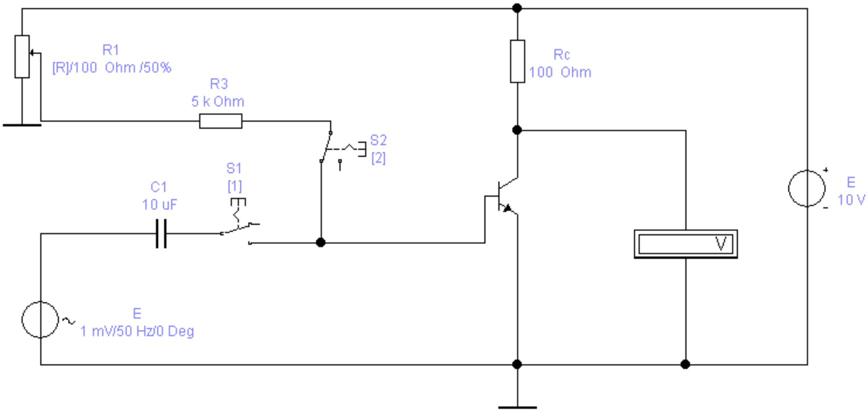


Figure 4.2 – Transistor amplifier circuit

Experiment №2

Investigation of the amplifier in low signal mode

4 Specify source options E according to the option. The parameters are presented in the table. 4.2.

5 Connect the oscilloscope to the source of the input signal and to the transistor collector. Connect the source of the input signal to the transistor base using the S1 switch.

6 Remove the oscillogram, determine the maximum and minimum voltages on the collector on it and the voltage gain of the cascade. Determine the maximum voltage of the source of the input signal, in which the output signal has an undamaged form.

Table 4.2 – Parameters of the voltage source

№ variant	1	2	3	4	5	6	7	8	9	10	11	12
E, B	5	6	7	8	9	10	5	6	7	8	9	10
f, Hz	100	200	250	300	400	450	500	600	80	850	900	1000

Control questions

1. Definition, classification, structural diagram, characteristics and parameters of the electronic amplifier.
2. Varieties and elements of the amplifier stages.
3. Point of rest of the amplifier cascade: definition, methods of the task
4. What is the difference between the phases between the input and output sinusoidal signals in the amplifier with CE and CC?
5. How does the input impedance affect the voltage gain?
6. Variety of distortions of the output signals of the amplifier
7. Is the output impedance of the amplifier with a high value?
8. What is the main advantage of the amplifier circuitry with CC?

Laboratory work №5

Objective: to investigate typical nodes on operational amplifiers - inverting, non-inverting, agitating, differentiating, and integrating amplifiers.

Brief theoretical data: an operating amplifier is called a high-quality integrated DC amplifier with differential input and one-step output. Opamps are used to amplify, limit, summate, filter, generate, stabilize signals in analog devices [1].

The gain of the circuit of the non-inverting amplifier on the opamp (Fig. 5.1) is determined by the formula:

$$Ks=1+R1/R2$$

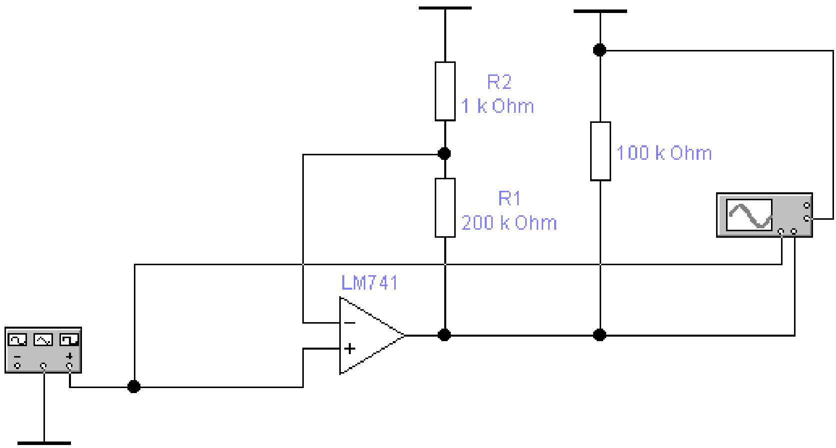


Figure 5.1 - Scheme of non-inverting amplifier

The gain of the circuit of the inverting amplifier on the Opamp (Fig. 5.2) is determined by the formula:

$$Rs = - R2 / R1.$$

The minus sign in the formula will indicate that the output voltage of the inverting amplifier is in the opposite phase with the input voltage.

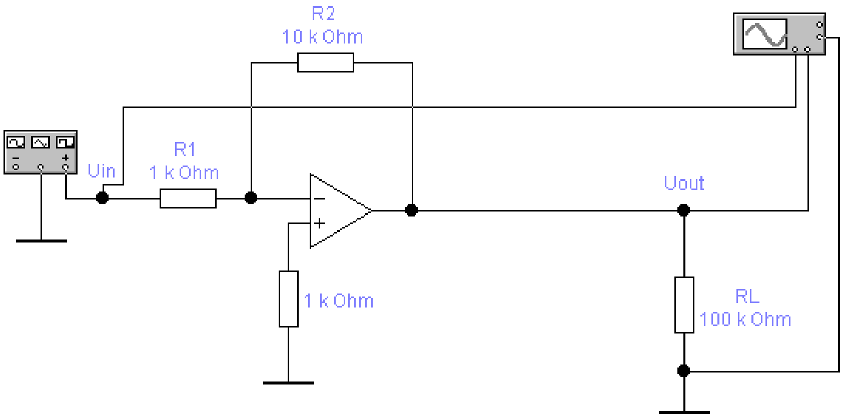


Figure 5.2 - Scheme of inverting amplifier

In the summing amplifier fig. 5.3, if the input currents and bias voltages are equal to zero, then the following ratios are performed:

$$I1 = U1/R1;$$
$$I2 = U2/R2,\ I = I1+I2;$$
$$Ioc = I1 + I2 = -U_{OUT}/Roc.$$

From these relations we obtain an expression for the output voltage:

$$U_{OUT} = -(I1+I2)*Roc = -(U1/R1+U2/R2)*Roc.$$

If Roc = R1 = R2, then $U_{OUT} = U1+U2$.

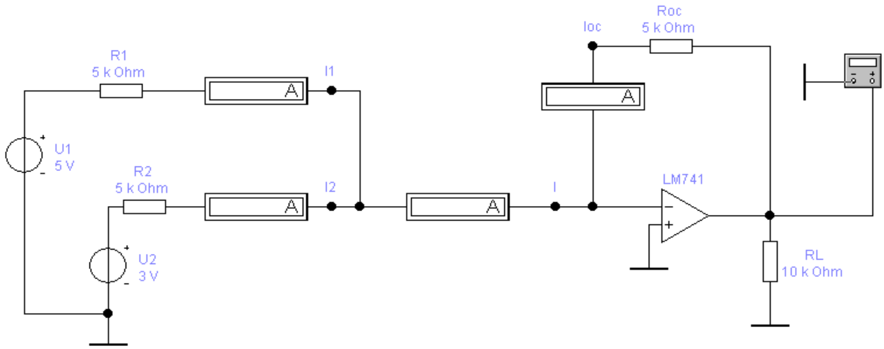


Figure 5.3 - Schematic of adding amplifier

On the basis of OP can be built integrators. Figure 4.5 shows a scheme that performs this function. The following relationships are valid for this scheme:

$$U_{IN}/R = -C*dU_{OUT}/dt,$$

$$U_{OUT} = -1/RC*\int_0^t U_{IN}*dt+const$$

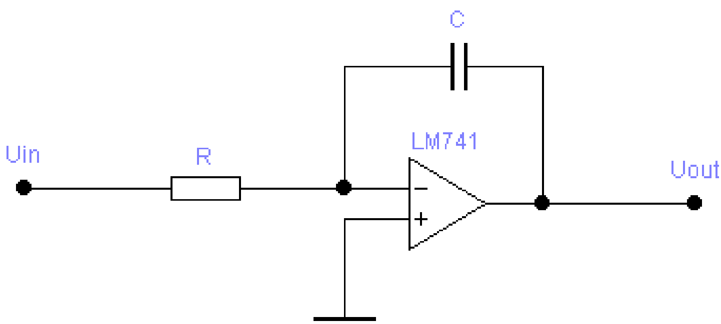


Figure 5.4 - Integrator scheme

For the differentiator circuit (Fig. 5.5), the output voltage Uout is proportional to the change in the input signal and is determined by the formula:

$$U_{OUT} = -R2 * C * \frac{dU_{IN}}{dt}$$

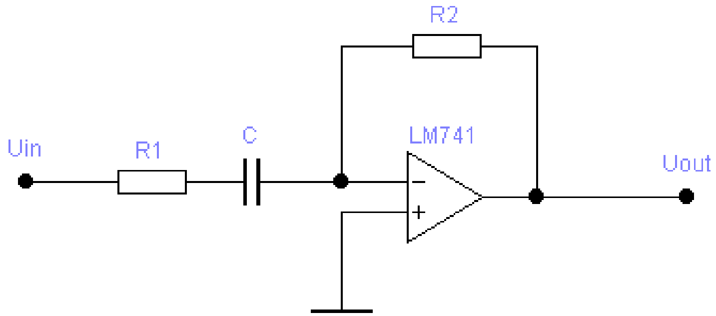


Figure 5.5 - Differentiator scheme

Motion of work

Experiment №1

Non-inverting amplifier

1 Draw a pattern Fig. 5.1.

2 Connect the oscilloscope and pulse generator.

3 Remove the oscillogram, determine the gain and compare with the calculated.

Experiment №2

Inverting Amplifier

4 Draw a pattern of Fig. 5.2.

5 Connect the oscilloscope and pulse generator.

6 Remove the oscillogram, determine the gain and compare with the calculated.

Experiment №3

Adding amplifier

1 Draw a diagram of Fig. 5.3.

2 Connect the multimeter.

3 Determine the output voltage and compare it with the calculated.

Experiment №4

Integrator

1 Draw the diagram Fig. 5.6.

2 Remove the oscillogram of the input and output voltage when applying voltage to the input in the form of successive rectangular pulses.

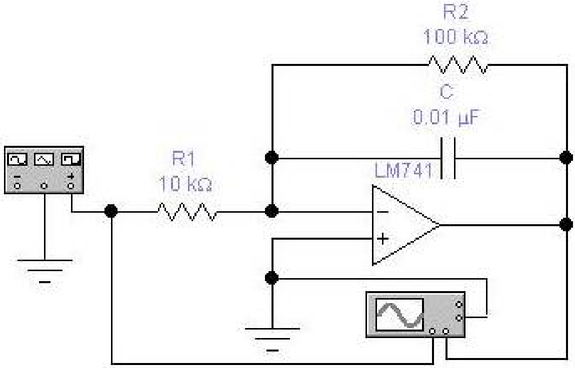


Figure 5.6 - Integrator scheme

Experiment №5

Differentiator

1 Draw a diagram of Fig. 5.7.

2 Remove the oscillogram of the input and output voltage when applying voltage to the input in the form of successive rectangular pulses.

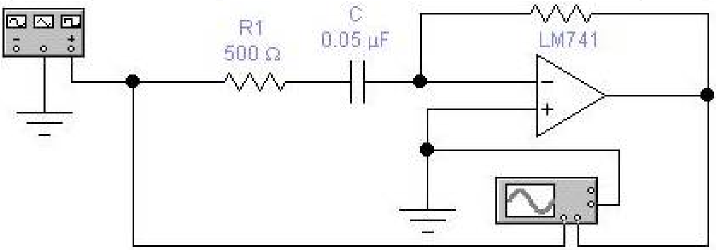


Figure 5.7 - Differentiator scheme

Control questions

1. What is an operating amplifier?
2. What is the difference between inverting amplifier and non-inverting?
3. Transfer characteristic of OP for inverting and non-inverting inclusion.

4. What are the default nodes for OPs?

5. Write formulas for the transfer coefficient for typical nodes in OPs?

Laboratory work №6

Objective: to investigate logical elements and functions.

Brief theoretical data: variables considered in algebra of logic can accept only two values - "0" or "1". In the algebra of logic defined: the relation of equivalence (denoted by the sign =); addition operation (disjunction), which is indicated by a sign or +; multiplication operation (conjunction), denoted by a sign or &; or a point; inversion operation denoted by an over-mark or apostrophe sign [1,2].

The algebra of logic is determined by the system of axioms:

$$\begin{cases} x = 0, \text{if } x \neq 1; \\ x = 1, \text{if } x \neq 0; \end{cases} \qquad \begin{cases} \bar{0} = 1; \\ \bar{1} = 0; \end{cases}$$

$$\begin{cases} 1 \vee 1 = 1; \\ 0 \vee 0 = 0; \\ 0 \vee 1 = 1 \vee 0 = 1; \end{cases} \qquad \begin{cases} 1 \wedge 1 = 1; \\ 0 \wedge 0 = 0; \\ 0 \wedge 1 = 1 \wedge 0 = 0; \end{cases}$$

Logical expressions are usually executed in conjunctive or disjunctive normal forms. In a disjunctive form logical expressions are written as a logical sum of logical sets, in a conjunctive form, the logical multiplication of logical sums. The procedure is the same as in ordinary algebraic expressions.

Any logical expression composed of n variables $x_n, x_{n-1} ... x_1$ using a finite number of operations of logic algebra can be regarded as some function of n variables. Such a function is called logical.

The following features of the two variables x and y represent the main interest:

f1 (x, y) = $x \wedge y$ - logical multiplication (conjunction),

f2 (x, y) = $x \vee y$ - logical addition (disjunction),

f3 (x, y) = $\overline{x \cdot y}$ - logical multiplication with inversion f4 (x, y) = $\overline{x \vee y}$ - logical addition with inversion

f5 (x, y) = $x\bar{y} \vee \bar{x}y$ - summing modulo "2",

f6 (x, y) = $xy \vee \overline{xy}$ - equilibrium.

A physical device that implements one of the operations of logic algebra or a simpler logical function is called a logical element. A schema composed of a finite number of logical elements working on defined rules is called a logical scheme.

Since the domain of the definition of any function of the n variable is finite, such a function can be given by a table of valuesf (Vi), which it accepts at points Vi, where i is 0,1,... 2^n -1. Such tables are called truth tables.

Motion of work

Experiment №1

Research Logical functions "and"

1 Follow the scheme fig 6.1.

2 Turn on the circuit, install a switch “B” at the bottom and then at the top position, then use a voltmeter on the input “B” and replace it with a logic probe for a logical signal.

3 Fare on entering the schema of the service can combo combining the logical signal “A” and “B” that for the leather combo fixing the signal “Y”.

4 Record a table of logistic schema “and”.

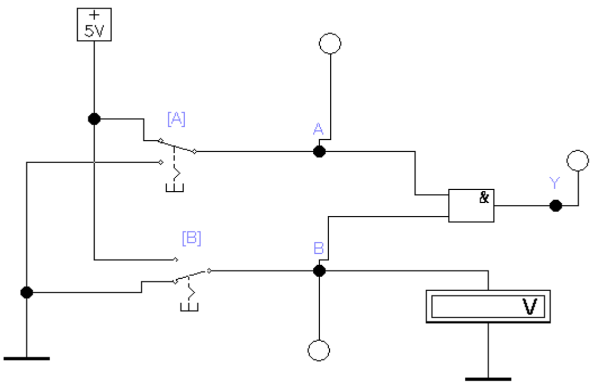


Figure 6.1 - Scheme for research logically functions "and"

Experiment №2

Investigation of logic circuits using the word generator

1 Draw a schematic diagram of Fig. 6.2.

2 Turn on the circuit.

3 Specify which terminals the chip "7400" connects to the power supply, how many elements "2And-No" in this chip, how many elements are used in this experiment, and as the inputs and outputs used in the scheme are indicated.

4 Set the generator to step-by-step operation by pressing the "Step" button on the magnified image of the generator. Each click of the "Step" button causes a transition to the next word of a given sequence, which is fed from the output of the generator. Serializing the words of a given sequence on a chip, fill in the truth table of the element "2And-No".

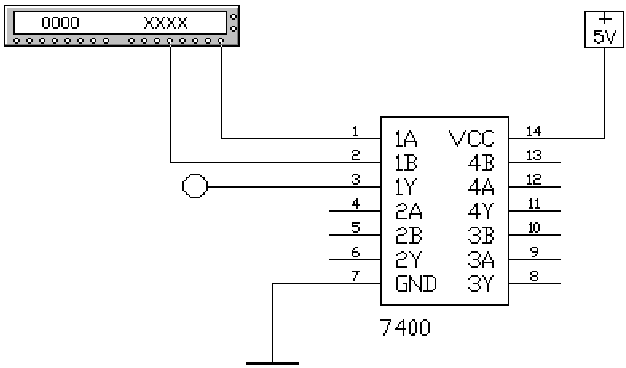


Figure 6.2 - Ship 7400

Experiment №3

Realization of the logical function of 3 variables

Realize the function $f = ab \vee \overline{b}c$ on elements "2And-No". To do this, follow these steps:

1 Call a logic converter.

2 Enter the logical expression from the keyboard in the bottom window of the converter panel (operations "OR" correspond to the + sign, the inversion is indicated by the apostrophe).

3 Press the A | B → NAND key on the logic converter panel and redraw the synthesized circuit.

4 To the scheme connect the word generator (Fig. 6.3), programmed to form 7 words, corresponding to numbers from 0 to 7: 0 = 000; 1 = 001; 2 = 010; 3 = 011; 4 = 100; 5 = 101; 6 = 110; 7 = 111.

5 Translate the word generator into step-by-step mode.

6 Turn on the scheme.

7 Serialize the specified words to the inputs of the circuit and determine the signal level at the output of the circuit with a logical probe, fill the truth table.

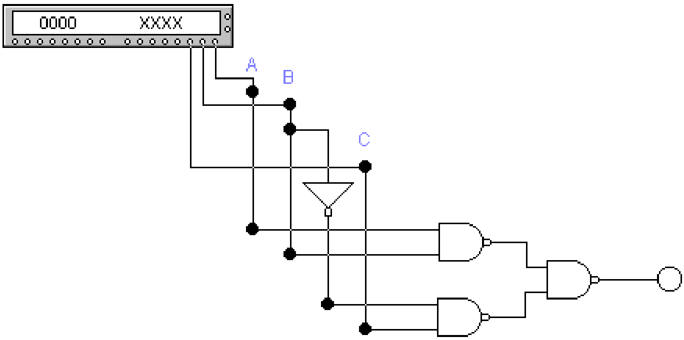


Figure 6.3 – Connection scheme of the word generator

Control questions

1. What is a logical variable and a logical signal? What values can they take?
2. What is a logical function and which ones do you know?
3. What is the truth table?

Laboratory work №7

Objective: to study the principle of the thyristor and how to activate it.

Brief theoretical data: a thyristor is a semiconductor device with three or more p-n transitions used in powerful circuits [1]. For the thyristor to be turned on, an on-line voltage is applied to its anode, which exaggerates the voltage of the thyristor. Another way to turn on the thyristor is to turn it on with a current through the thyristor control electrode. Simistor is a kind of thyristor, which can go into an activated state both in the direct and at the return voltage at the anode.

Motion of work

Experiment №1

Investigation of thyristor when UE <UVDRM

1 Draw a diagram of Figure 7.1.

2 The value of the amplitude of the input voltage source is set to be less than the value of the forward breakover voltage (VDRM) parameter of the thyristor model.

3 Connect the oscilloscope, remove the oscilloscope.

4 Determine the operation mode of the thyristor.

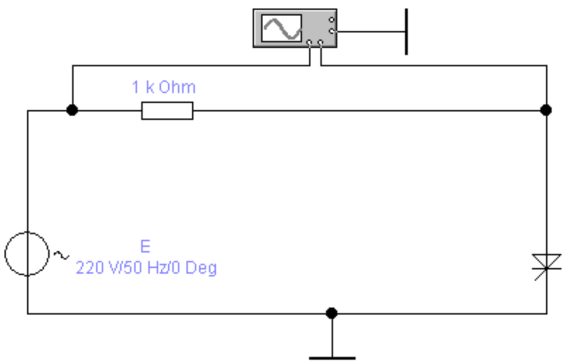


Figure 7.1 - Turn on the thyristor on the anode circuit

Experiment №2

Thyristor research when UE> UVDRM

1 Repeat Experiment # 1, but the value of the amplitude of the input voltage source is set to be greater than the value of the forward breakover voltage (VDRM) parameter of the thyristor model.

2 Connect the oscilloscope, remove the oscilloscope.

3 Determine the operation mode of the thyristor.

Experiment №3

Turn on the thyristor in the control circuit

1 Draw a schematic diagram of Figure 7.2.

2 The value of the amplitude of the input voltage source is set to be less than the value of the forward breakover voltage (VDRM) parameter of the thyristor model.

3 Connect the oscilloscope, remove the oscilloscope.

4 Determine the operation mode of the thyristor and the thyristor start delay angle.

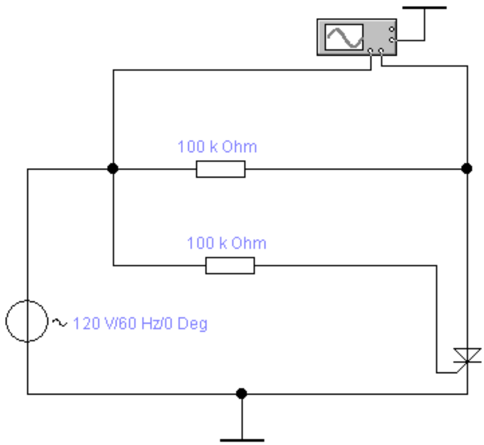


Figure 7.2 - Увімкнення тиристора по ланцюгу керування

Experiment №4

The study of the simistor

1 Draw a schematic diagram of Fig. 7.3.

2 The value of the amplitude of the input voltage source is set to be less than the value of the VDRM parameter of the thyristor model.

3 Connect the oscilloscope, remove the oscilloscope.

4 Determine the simistor operation mode and the timing delay of the simistor.

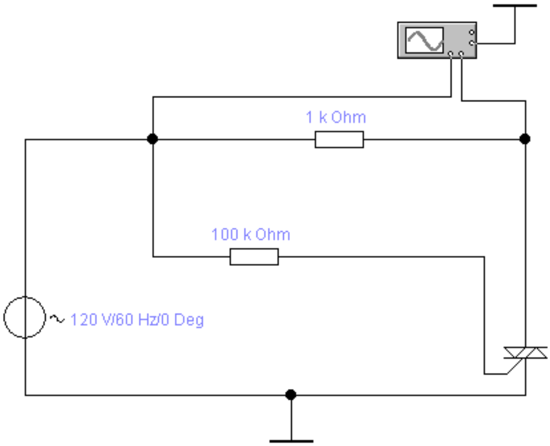


Figure 7.3 – The simister research

Control questions

1. What is called a thyristor?
2. What types of thyristors do you know?
3. Draw a diagram of the thyristor.
4. Draw and explain the VHF thyristor.
5. Differences between the thyristor of the simistor.

Laboratory work №8

Objective: To explore passive filters electronic devices based RC- and LC-circuits.

Brief theoretical data: in electronics it is often necessary to allocate a signal of a given frequency from the whole set of information and parasitic signals that enter the device's input. For this purpose, various frequency-selective schemes are used, which are called filters [1,3]. The basis of any filter is the RC or LC chain, which is a passive part of the whole electronic device, that is, it is a passive filter. It is the passive filter that allocates the signals of the given frequencies from their entire spectrum, while the other part of the device performs an analog operation to amplify or generate this signal.

Common filter response specifications are described as follows:

1A low-pass filter (LPF) passes low frequencies while blocking higher frequencies (See Fig. 8.1).

2A high-pass filter (HPF) passes high frequencies.

3A band-pass filter (BPF)_ passes a band (range) of frequencies.

4A band-stop filter (BSF) passes high and low frequencies outside of a specified band.

The main characteristics of the filters are amplitude-frequency - Fig. 8.2 and phase-frequency - Fig. 8.3. The frequency response is the dependence of the transmission coefficient of the filter on the frequency. The FHC frequency response frequency response characteristic is the dependence of the phase shift of the output signal relative to the input signal. The transmitter frequency of the frequency filter is expressed in decibels.

$$K\ [dB] = 20 \lg K,$$

where: K [dB] - gain in decibels;

K is the gain in relative units:

$$K = Uout/Uin.$$

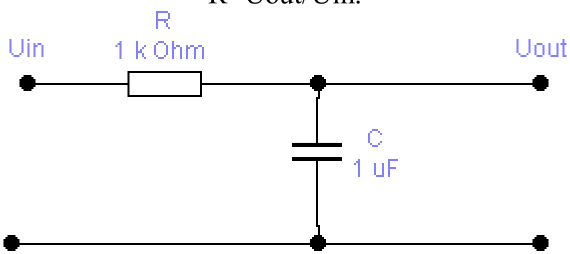


Figure 8.1 - Low pass filter (LPF))

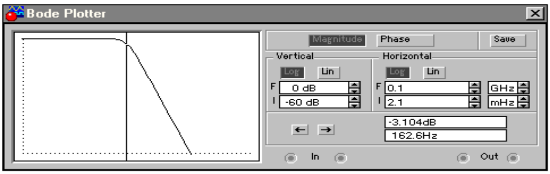


Figure 8.2 - Graphic representation characteristic K=F(f) in Bode Plotter

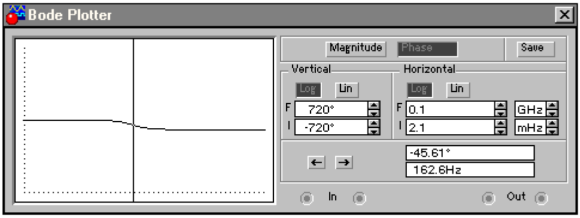


Figure 8.3 - Graphic representation characteristic φ=F(f) in Bode Plotter

At the frequency f_0 of the equal signal, the maximum value U_{OUT} decreases by $\sqrt{2}$ times. When $f > f_0$ the output voltage decreases with increasing frequency at a rate of 20 dB / dec, ie, with an increase in frequency 10 times (for a decade), U_{OUT} decreases by 10 times. The frequency range from 0 to the f_0 LPF bandwidth is called.

High-frequency filters (HFF) are characterized by the same parameters as the LPF.

The main parameter for a band-stop filter (BSF) is the quasi-resonance frequency f_0:

$$f_0 = 1 / 2\pi R_1 C_1$$

The bandwidth of the T-bridge Δf is defined as the frequency difference at which the output voltage U_{OUT} of the filter (at a given U_{IN}) is 0.707 from the maximum value on the LFF and HFF slopes. Knowing Δf, you can determine the Q factor of the Q filter as:

$$Q = f_0 / \Delta f$$

The calculation of the parameters of the scheme for the band-pass filter (BPF) is the same as for the BSF.

Motion of work

Experiment №1

LPF research

1 Draw a pattern of Fig. 8.4.
2 Connect the Body Plotter.
3 Determine the frequency response and phase response.
4 Determine the frequency f_0 response and compare with the estimated data.
5 Determine the offset angle for f_0.
6 Determine the rate of change in the transfer coefficient of the filter.

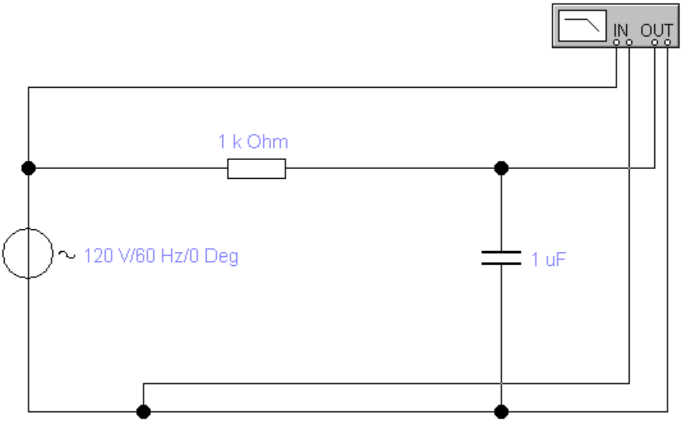


Figure 8.4 - Low pass filter

Experiment №2

A multi-line RC low pass filters research:
1 Draw a pattern of Fig. 8.5.
2 Connect the Body Plotter.
3 Determine the frequency response.
4 Determine f_0 on the frequency response and compare with the estimated data.
5 Determine the offset angle for f_0.
6 Determine the rate of change in the transfer coefficient of the filter.

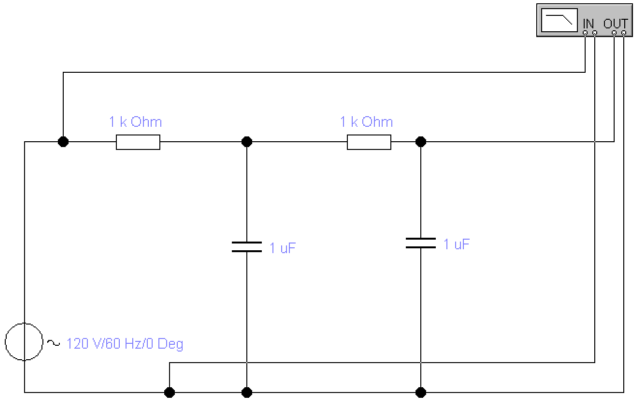


Figure 8.5 - Two-point low-pass filter

Experiment №3

High-frequency filter research

1 Draw a diagram of Fig. 8.6.

2 Connect the Body Plotter.

3 Determine the frequency response.

4 Determine f_0 on the frequency response and compare with the estimated data.

5 Determine the offset angle for the f_0.

6 Determine the rate of change in the transfer coefficient of the filter.

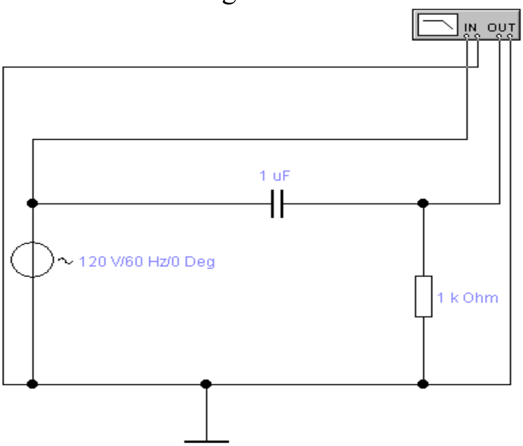


Figure 8.6 - High pass filter

Experiment №4

A multi-line RC high frequency filters research:

1 Draw a pattern of Fig. 8.7.

2 Connect the Body Plotter.

3 Determine the frequency response.

4 Determine f_0 on the frequency response and compare with the estimated data.

5 Determine the offset angle for f_0.

6 Determine the rate of change in the transfer coefficient of the filter.

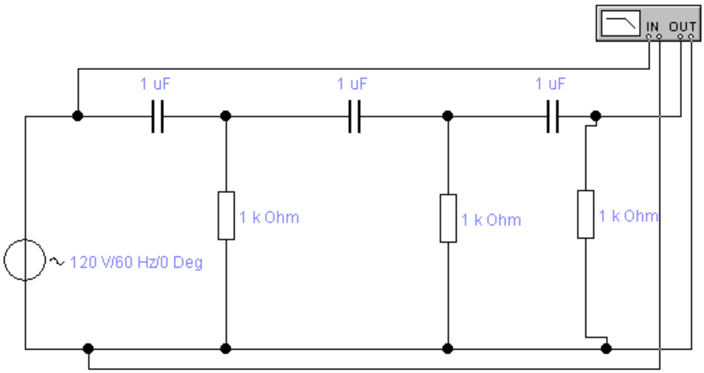


Figure 8.7 – Three-Way High-Frequency Filter

Experiment №5

A band-stop filters research:

1 Draw a pattern of Fig. 8.8 and connect the Bode Plotter.

2 Determinate the frequency response.

3 Determine the frequency f_0 and bandwidth of the barrier by frequency response and compare it with the estimated data.

4 Determine the offset angle for the f_0.

5 Determine the quality factor of the filter

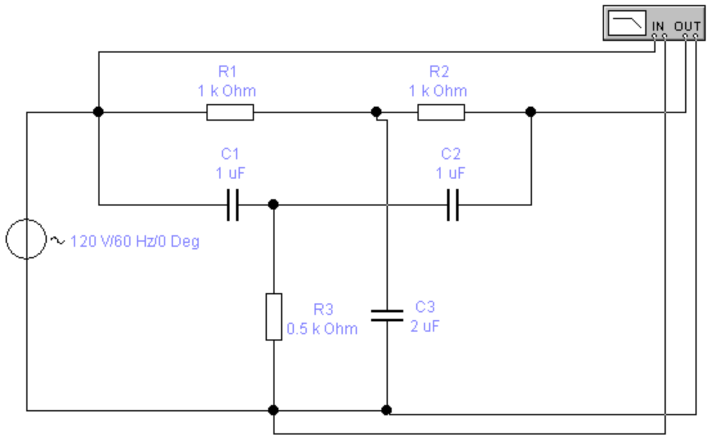


Figure 8.8 - Scheme of double T-shaped bridge

Experiment №6

A band-pass filters research:

1 Draw a pattern of Fig. 8.9 and connect the Bode Plotter.
2 Determinate the frequency response.
3 Determine the frequency f_0 and bandwidth of the barrier by frequency response and compare it with the estimated data.
4 Determine the offset angle for the f_0.
5 Determine the quality factor of the filter

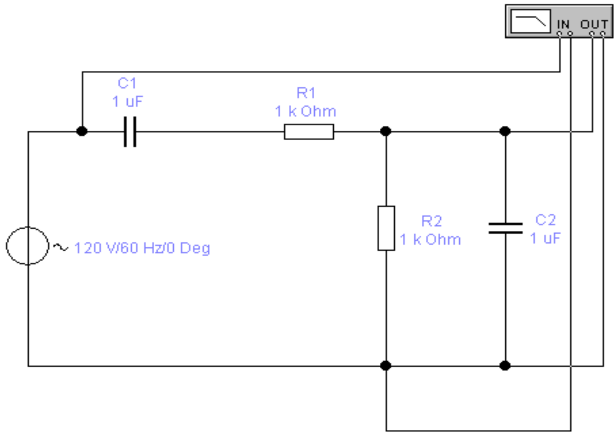


Figure 8.9 - Схема моста Віна

Control questions

1. What is a filter?
2. What are the main types of filters you know?
3. What is an amplitude-frequency characteristics and what parameters do they depend on?
4. What are the main parameters of the LPF you know?
5. What is decibel and decade?
6. Describe the principle of the band-pass filter and band-stop filter (and what parameters they are characterized.
7. Where are the filters used?

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